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I.—*Presidential Address: Some Points in which American Geological Science is indebted to Canada.* By SIR J. WILLIAM DAWSON, C.M.G., LL.D., F.R.S.

(Read May 26, 1886.)

The position of Canada relatively to original work in Geological Science, is somewhat peculiar. Its territory embraces the whole series of geological formations, and is second to no other in the interest of its rocks and minerals, and the extent and excellence of its exposures. It is thus rich in the raw material of geological discovery. But its skilled and trained workers have heretofore been few. It is deficient in great libraries and in the apparatus of original research. It possesses no wealthy institutions able to render substantial aid, either to research or publication. Its Government has been unable to devote large sums to geological explorations, and such aid as it has given has been too much restricted to merely economic explorations.

With all this, it lies beside a much greater and more wealthy country, into which all its rock formations extend, and which excels it tenfold in number of workers, in means of publication, and in government aids to science. It would be too much to expect that this powerful neighbour and those who enjoy for the time its advantages, should always be generous, forbearing, or even just, or that they should fail to use to the utmost their superior vantage in the race for distinction. Practically, while Canada has had much reason to be grateful for the friendly and generous sympathy of the naturalists of the United States, it has had occasion, in some happily exceptional cases, to smart under their vigorous competition, and in some instances to deprecate a spirit of detraction or of unfair rivalry.

It is interesting in these circumstances to enquire what Canada has done in promoting the advance of Geological Science, and how far she has been able to keep pace with or anticipate discovery abroad. In directing your attention to a few facts bearing on this question, I shall not hesitate to include with our own native workers, those who have come to us from the mother countries of our population, just as in the United States it is customary to regard the great men who have been imported from abroad as Americans.

Perhaps the simplest way will be to begin with the older formations, and to notice Canadian discovery as it applies to the different successive periods of geological time, as represented in our country.

Canada has magnificent exposures of the oldest rocks. Our vast Laurentian and Huronian territory is unsurpassed in extent and importance. In this, therefore, we should have some claims to honourable distinction. That we have such is evidenced by the fact that the names "Laurentian" and "Huronian" are of world wide currency, and the discussions as to the origin and character of these old rocks, and their possible evidence of primitive forms of life, have centred around Canadian localities and specimens.

In this field, Canada has had some eminent workers. The ground was broken in 1823

by Dr. Bigsby's "Notes on the Geography and Geology of Lake Huron."¹ In this he sketched the primitive rocks of Canada, as extending from the north-east of Lake Winnipeg, passing thence along the northern shores of Lakes Superior, Huron and Simcoe, and after forming the granitic barrier of the Thousand Islands, spreading themselves largely throughout the State of New York. He also notices the principal varieties of gneiss and other old rocks, and recognizes their stratified character. About the same time, Richardson published his notes on the geology of Franklin's northern expedition.

This was followed up by important papers by Bayfield on the "Geology of the North Coast of the St. Lawrence"² and on Lake Superior,³ and by papers on the Labrador coast and St. Paul's Bay by Lient. Baddeley,⁴ while Ingall described the country drained by the St. Maurice.⁵ Baddeley's papers in particular, published in the early volumes of the Transactions of the Literary and Historical Society of Quebec, show much accurate knowledge of rocks and minerals and attention to stratigraphical relations, while in all these papers there is a clear discrimination between the old crystalline rocks and the overlying "transition" beds holding fossils.

It is not too much to say that these researches between the year 1820 and the institution of the Geological Survey of Canada in 1842, which have been well summed up by Dr. Harrington in his "Life of Sir William Logan," placed Canada for the time in a very advanced and honourable position.

But the work of Sir William Logan, beginning in 1842 and continuing until his death, marks an epoch not only in our knowledge of the Laurentian and Huronian in Canada, but throughout the world. Logan in his preliminary report notices that the labours of Bayfield, Bigsby, Baddeley, Wilson, Green and others, had before his time shown that the primary rocks, as he then termed them, "form a continuous line from one end to the other of Northern Canada." In his report for 1845, using Lyell's term "metamorphic," he defines the existence of a lower group of gneiss and of an overlying group containing crystalline limestones. He also at this time recognized the still higher formation subsequently called "Huronian," and a little later the distinctive characters of the Upper Laurentian were established. It was in 1854 that the name "Laurentian" was proposed in Logan's report for that year.

An attempt has recently been made by certain American writers, not, I am happy to say, men of much estimation in their own country, to belittle Logan's work, and even to throw doubts on the validity of the magnificent stratigraphical investigations by which he finally established the fact of the continuity and bedded character of the Laurentian system and the sequence of its deposits. These detractions might well be passed over in silence; but I may say here that, having gone over several of Logan's Laurentian sections with his maps and notes as my guides, I can testify to the minute accuracy of his work, and to the care and sagacity with which he had unravelled the relations of these difficult and disturbed formations. I have also much pleasure in knowing that the most eminent of the later writers on the Western Geology of the United States, like Chamberlin and Irving, fully accord with Logan's conclusions, which have long been accepted by the best authorities in Eastern America and Europe.

¹ Trans. Geol. Soc., Vol. i. Sec. ii. p. 175.

² Trans. Lit. and Hist. Soc. of Quebec, Vol. i.

³ *Ibid.* Vol. v. (1833) Sec. ii. p. 89.

⁴ *Ibid.* Vol. i.

⁵ *Ibid.* Vol. ii.

Having been myself mixed up with the farther questions that have arisen as to the animal nature of Eozoon, and the vegetable origin of the abundant graphite of the Middle Laurentian, I shall say nothing of these farther than this, that if our Canadian conclusions should be substantiated, we shall stand here also in advance of the rest of the world.

In like manner I abstain here from entering into the question of the validity of the Montalban, Taconian and Keweenaw of our colleague, Dr. Hunt, which are now subjects of earnest discussion, but I believe are in great part, at least, based on natural facts perceived by Logan in his original examinations of the Pre-Cambrian formations of the west, but more distinctly defined by Hunt, and which may eventually give a new triumph to Canadian geology. I may say here that my own observations have convinced me of the reality of the succession of (1) a Lower Laurentian series, the Trembling Mountain gneiss of Logan; (2) a Middle Laurentian, the Grenville series of Hunt; (3) an Upper Laurentian, the Labradorian or Norian series; (4) the Huronian series; (5) the Animikie series; (6) the Keweenaw series. All these, except, perhaps, the last, are Pre-Cambrian, and belong to the Eozoic period. Of the Montalban I cannot speak so certainly. There is such a series, and this of great importance; but I do not know from my own observations its precise geological position.

I need scarcely say that the researches of Dr. Hunt in the chemical and dynamical geology of these ancient rocks and their relations to the origin of continents and mountain chains stand unsurpassed, and of themselves give to Canada a clear title to preëminence in this department.

Before leaving this subject, I may mention an attack which has been made on Sir W. Logan by an American writer, on the ground that the name "Laurentian" had been preoccupied by Desor. It seems that the latter had used the word "Lawrentian" to express the Pleistocene deposits of the St. Lawrence valley. But the name never gained any currency, and Logan's use of the term, "Laurentian," for the old crystalline series was only a little later,—Logan having applied the name in 1854, while Desor's use of the similar name "Lawrentian," had occurred in 1851. Logan and Hunt, who coöperated in the matter, based the name, not on the St. Lawrence River, but on the old name *Laurentides*, applied by Garneau to the mountain range composed of these rocks. In point of fact, the name "Laurentian" was based on the mountains composed of these rocks, and the name "Lawrentian" on the river itself; and the latter fell to the ground as useless and inappropriate.

The discovery of the rich Cambrian Fauna of St. John, New Brunswick, and in connection with this, that of the fossil plants of the neighboring Devonian beds, belong to the late Prof. C. F. Hartt, and to our colleagues, Mr. G. F. Matthew and Prof. Bailey. Of these discoveries I have remarked: "The collection and determination of the Cambrian fossils of what is now known as the Acadian group, and the excavation of the numerous Devonian plants of the same district, constitute in my judgment two of the most important advances ever made in the paleontology of Eastern America." Hartt published his first report on these fossils in 1865, and they were more fully described and illustrated in the second edition of my "Acadian Geology" in 1868. It is true that long before this time the *Paradoxides Harttani* of the Massachusetts shales had been discovered, and Emmons had endeavoured to illustrate the fossils of the Taconic system. But little attention had been given

to these facts, though as early as 1852 they had attracted the attention of the great Bohemian palæontologist, Barrande. Any one who studies the magnificent volumes of Hall, or the earlier editions of Dana's manual, will see that, until Hartt's discoveries were made, the view of American geologists scarcely extended lower in the Palæozoic than the Potsdam sandstone. The work so well begun by Hartt has been followed up by Matthew, and we have, in the last volume of our Transactions, a memoir in which many new forms are added to this ancient fauna, and we hope at our present meeting to have for the first time a subdivision of its fossils according to age, parallel to that ascertained in Western Europe. In a paper to be read at the present meeting, Mr. Matthew is able to tabulate sixty-five species and twenty-one varietal forms, from the lowest division of the Acadian group, corresponding to the earlier Cambrian of Europe.

A curious accident has recently happened in connection with Hartt's collections. These remained after his death in the United States, and were offered for sale, and should have been acquired for our Canadian collections. The fossil plants I purchased at my own expense for the McGill College collection, but the primordial fossils I had not means to redeem, and the Survey was at the time equally impecunious. They remained consequently in Cornell University, and Hartt's types, which Mr. Matthew should have had as the basis of his work, have been republished as a Bulletin of the United States Geological Survey, illustrated in a far more sumptuous manner than I was able to afford in my "Acadian Geology," and there can be little doubt that the effect will be that abroad an officer of that Survey will practically receive the credit which should belong to Canadians, though he has done little if anything to advance the knowledge of the subject beyond the point where Hartt left it. Prof. Bailey, who has been following up the stratigraphy of these rocks as ably as the fossils have been worked by Matthew, has directed my attention to the fact that in a recent, somewhat pretentious volume issued in Cambridge, the work of Canadian geologists in these rocks is sneered at, and that by unfair citations of statements made at different times and during the progress of discovery, we are made to appear as at variance with one another. On this subject I would say that, in my own connection with the geology of the Maritime Provinces, I have ever endeavoured to promote the work of my younger geological friends; have at once admitted any new discovery, even when contradicting the conclusions I had formed from a less complete induction of facts; and that the work of Hartt, Matthew and Bailey in the complicated and disturbed coast rocks of southern New Brunswick has produced results in stratigraphy and palæontology more accurate, complete and important in the interests of science, than any that can be shown with reference to the continuation of these same rocks in New England.

If the holding of different opinions on debatable points, and the free and active discussion of these opinions is to be a ground of accusation against Canadian geologists, I fear the next great group of rocks, that Siluro-Cambrian series to which Logan gave the name "Quebec Group," may afford more ground of complaint. It would be useless here to attempt to summarize the discussions in which Hall, Emmons, Dana, and many other American geologists have taken part, or the bold and masterly way in which Logan and Billings cut the Gordian knot, or the subsequent discussions of Hunt, Selwyn and Macfarlane. I have elsewhere noticed these subjects, and hope to do so again before long. I may content myself with quoting a general statement on the subject, made in 1879, and still I think correct.

When Sir William Logan commenced the Geological Survey of Canada in 1842, the older rocks, in so far as his field was concerned, were almost a *terra incognita*, and very scanty means existed for unravelling their complexities. The "Silurian System" of Murchison had been completed in 1838, and in the same year Sedgwick had published his classification of the Cambrian rocks. The earlier final reports of the New York Survey were being issued about the time when Logan commenced his work. The great works of Hall on the palæontology of New York had not appeared, and scarcely anything was known as to the comparative palæontology and geology of Europe and America. Those who can look back on the crude and chaotic condition of our knowledge at that time, can alone appreciate the magnitude and difficulty of the task that lay before Sir William Logan. To make the matter worse, the most discordant views as to the relative ages of some of the formations in New York and New England which are continuous with those of Eastern Canada, had been maintained by the officers of the New York Survey.

Sir William made early acquaintance with some of these difficult formations. His first summer was spent on the coast of Gaspé and the Baie des Chaleurs, where he saw four great formations, the Quebec group, the Upper Silurian, the Devonian, and the Lower Carboniferous, succeeding each other, obviously in ascending order, and each characterized by some fossils, most of which, however, were at that time of very uncertain age. I remember his showing me in the autumn of that year the note-books in which he had carefully sketched the stratigraphical arrangements he had observed, and also the forms of characteristic fossils. But both wanted an interpreter. The plants of the Gaspé Devonian were undescribed; many of them of forms till then unheard of. The shells and corals and graptolites of the older formations could be only roughly correlated with some of those in the New York reports. The rock formations are very unlike those of the New York series. Still this work of 1842 and 1843 was plain and easy, compared with that which arose in tracing these formations to the south-west. I may add here that I have since studied some of these Gaspé sections with Sir William's manuscript note-books in my hand, and have been amazed at the extraordinary care and exactitude with which every feature of the rocks had been observed and noted down. Much of the detail in these early note-books of Sir William still remains unpublished. Those who would detract from the work of Sir William Logan, if there are any such, should remember these early beginnings, and compare them with the massive foundations which have been laid for us to build upon.

And now, after the labour of more than thirty years on the part of Sir William and those he had gathered around him, how do these subjects stand? (1) We have all the comparatively flat and undisturbed formations of the great plains of Upper and Lower Canada, our share of the interior continental plateau of America, worked out and mapped, and their fossils characterized so that a child may read them. (2) The complex hilly districts, with their contorted, disturbed and altered beds, which extend from New England to Gaspé, have been traversed in every direction, the limits of their different formations marked, and a theory as to their age and structure put forth, which, whether we accept it or not, has in its important features of the truth, and rests on facts on which every disputant must take his stand. (3) We have the still older formations of the Laurentian hills traced in their sinuous windings, and arranged in an order of succession which must stand whether the names given by Sir William, and now accepted throughout the world, be objected to or not. After the work of Sir William Logan, no cavilling as to names can ever

deprive Canada of the glory of being the home of the scientific exploration of the Laurentian; and much examination of the ground which he explored enables me to affirm that no one will ever be able permanently to overset the general leading subdivisions which he established in the Laurentian and Huronian systems.

We may sum this matter up, in so far as Sir William Logan's work is concerned, and that of his assistants, and of Hall and Billings in the department of palæontology. Their researches have established:—(1) The general diversity of mineral character in the Palæozoic sediments on the Atlantic slope as compared with the internal plateau of Canada. In these results Bailey, Matthew and Hartt in New Brunswick, and the writer in Nova Scotia, have also borne some part. (2) The establishment of the Quebec group of rocks as a series equivalent in age to the Calciferous of America, and to the Arenig and Skiddaw of England, and the elucidation of its peculiar fauna. (3) The tracing out and definition of the peculiar faulted junction of the coastal series with that of the interior plateau, extending from Quebec to Lake Champlain. (4) The definition in connection with the rocks of the Quebec group, by fossils and stratigraphy, of formations extending in age from the Potsdam sandstone to the Upper Silurian, as in contact with this group, in various relations, along its range from the United States frontier to Gaspé; but the complexities in connection with these various points of contact, and the doubts attending the ages of the several formations, have never yet been fully solved in their details. (5) The identification of the members of the Quebec group and associated formations with their geological equivalents in districts where these had assumed different mineral conditions, either from the association of contemporaneous igneous beds and masses, or from subsequent alteration, or both. It is with reference to the results under this head, the most difficult of all, that the greater part of the objections to Sir William's views have arisen, and that recent discussions and observations have somewhat modified his conclusions.

I may be permitted to add that we hope to have at this meeting a communication from Prof. Lapworth, so well known as an authority on Graptolites, in which he compares the fossils of this group found in Canada with those of Europe, and while giving important new light on the whole subject, substantiates the conclusions previously arrived at by Canadian geologists, and published in local reports and periodicals.

In the wide-spread Siluro-Cambrian, Silurian and Devonian formations of the great interior plateau of the American continent, the geologists of the State of New York have had the start of us, and Hall stands *facile princeps* as their interpreter. Hall has, indeed, by his services to Canadian palæontology, as well as to that of the United States, entitled himself to adoption as a Canadian, and has been so adopted by various societies and institutions, but next to him we have a right to place Billings, whose accurate work and sagacious insight are unsurpassed, and whose industry is evidenced, as I am informed by his successor, by his descriptions of more than one thousand new species and sixty-nine new genera, while he has added not merely to our catalogue of Canadian fossils but to the knowledge of the world. Another special claim of Canada is that to the ownership of the Guelph formation, a fossiliferous group wanting in the State of New York, and thus filling a gap in the history of life in the Silurian age in America. The fossils of this formation were studied by Mr. Billings, and still more recently the collections of Mr. Townsend, a local collector, have been described by Mr. Whiteaves, and have added several new fauna to those previously known.

Of those upper members of the Palæozoic series with which I am myself most conversant, I shall not say much. Canada has taken the lead in the discovery of insects of the Devonian or Erian period. We have discovered and described more of the land plants of that period than are known in any other country, perhaps in all other countries; and the Devonian flora of Canada is the term of reference and comparison for that of all other countries. New interest has been added to the Erian of America by the discovery, first made known by Mr. Ellis, of fossil fishes in rocks of this age at the mouth of the Restigouche River, a discovery followed up by Mr. Foord, and by the description of the specimens by Mr. Whiteaves. The results are a Lower Devonian fish fauna characterized by *Cephalaspis* and *Coccosteus* and two species of selachians, and an Upper Devonian fauna affording *Pterichthys*, *Phaneropleuron*, etc., in all eight species. It is interesting to note that these faunas are associated with plants characteristic respectively of the Lower and Upper Devonian.

Much has been done in the Carboniferous flora, and more especially in the discrimination of its successive stages, from the Lower Carboniferous to the Permian. To us science owes the earliest discovery in America of Carboniferous batrachians, the oldest stomapod crustacean, and the first known palæozoic land shells and millipedes; and some of our grand coast sections and exposures of Carboniferous rocks have become as familiar as household words to the geologists of every country.

Canada is not richly endowed with rocks of the early Mesozoic age, except perhaps in those western districts as yet only imperfectly explored. Our Triassic rocks and their associated trappean beds were very early studied, and though here we owe much to Jackson and Alger, we have also done much for ourselves. I was amused not long ago to see relations of the trappean rocks to the red sandstones long ago established in Nova Scotia, only beginning to be applied to the similar rocks of Connecticut and New Jersey.

Our Cretaceous and Tertiary rocks of the Northwest are only as yet partially explored. Still we have already done something to elucidate their structure. The work of Dr. Selwyn, Mr. Richardson, Dr. G. M. Dawson and Mr. Whiteaves, has thrown much new light on their age and distribution, and we have, I think, taken the lead in disentangling the confusion introduced into their flora by a too rigid adherence to arbitrary classifications introduced into palæobotany in Europe. We can show in the Transactions of this Society the first clear and consecutive sequence of plants from the Lower Cretaceous into the Eocene, and the conclusions based many years ago on collections made in Canadian territory, are only now being introduced to notice and recognized as correct in the United States.

In this connection an important discovery has been made by Mr. Whiteaves in the study of the fossils collected by Mr. Richardson and Dr. G. M. Dawson, in the Queen Charlotte Islands. Mr. Whiteaves, whose previous studies in English Mesozoic fossils entitle him to be regarded as an authority in this matter, finds evidence that beds of the age of the English Gault exist in these western regions, and that a portion of the so-called Jurassic of the western territories of the United States, is probably Lower Cretaceous. This fact brings the geology of the West more into harmony with that of the eastern part of America, which seems to have been dry land during the Jurassic period. I find, however, that, in a recent article in the "American Journal of Science," Mr. Whiteaves complains, apparently with justice, that while his conclusions have been only partially accepted, credit is denied

for the corrections introduced by him, and even the collections and stratigraphical observations on which his results were based, are disparaged.

The quiet way in which the American palaeontologist speaks of the collections made by Richardson and Dr. Dawson as "some fossils," "reported to come from certain beds," when these extensive collections are known to be accompanied with the most careful stratigraphical work, would be amusing if it were not provoking. It is only to be paralleled by the similar simplicity of some European palaeontologists. One of these, in discussing the nature of Eozoon laments that no accurate geological work has been done on the Canadian Laurentian. Another, when affirming the Cretaceous plants of Vancouver Island to be Miocene, speaks of the geology of this island as quite unknown, and a third coolly assumes the Devonian beds of New Brunswick to be Carboniferous, because he supposes that no one has explored the stratigraphy of these unknown regions!

In the disputed questions of Pleistocene geology it would be premature to make any boast. I may say, however, that the Canadian school of geologists has distinguished itself by moderate views as to the Glacial period. The fact that we can study on our own coasts many of its operations still in progress has contributed to this. We have also the advantage in the St. Lawrence valley and the western plains of a vast horizontal distribution of Pleistocene beds, and of very rich fossiliferous deposits. Certain it is that we have taken the lead in working out the fauna and flora of the so-called "Glacial Period," and have so far avoided those more extreme notions of continental glaciation which have gained currency in the United States. I feel convinced that ultimately our caution in this will be vindicated, and that we shall find that the sober afterthought of geologists will refer the glaciation of rocks and the transport of boulders quite as much to the action of marine currents and floating ice as to land glaciers. A powerful reaction is taking place in this direction in Europe, and though the influence of certain great names still upholds in the United States very extreme views as to the Glacial Age, they must soon be toned down within the limits demanded by our knowledge of physical facts and possibilities.

I have been able to refer only very generally to a few of the leading departments of geological discovery in which this country has taken the lead or has successfully followed. Enough has been said to show that though Canadian science labours under many disadvantages, its votaries have not thereby been deterred from working, and that their labour has not only been crowned with a fair measure of success, but that they have in many cases been able to act as teachers to those who might be supposed to have advanced far beyond them. It remains to our younger men to uphold and extend our good reputation in these respects, and I trust that as many of them have been favoured with educational advantages beyond those of their predecessors, they may also be supplied with greater facilities for exploration and publication, and that our public men will beware of falling into the popular mistake of limiting our scientific expenditure by a narrow and slavish utilitarianism which defeats its own ends.

